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PONDEROSA PINE SEED — FOR ANIMALS OR TREES?

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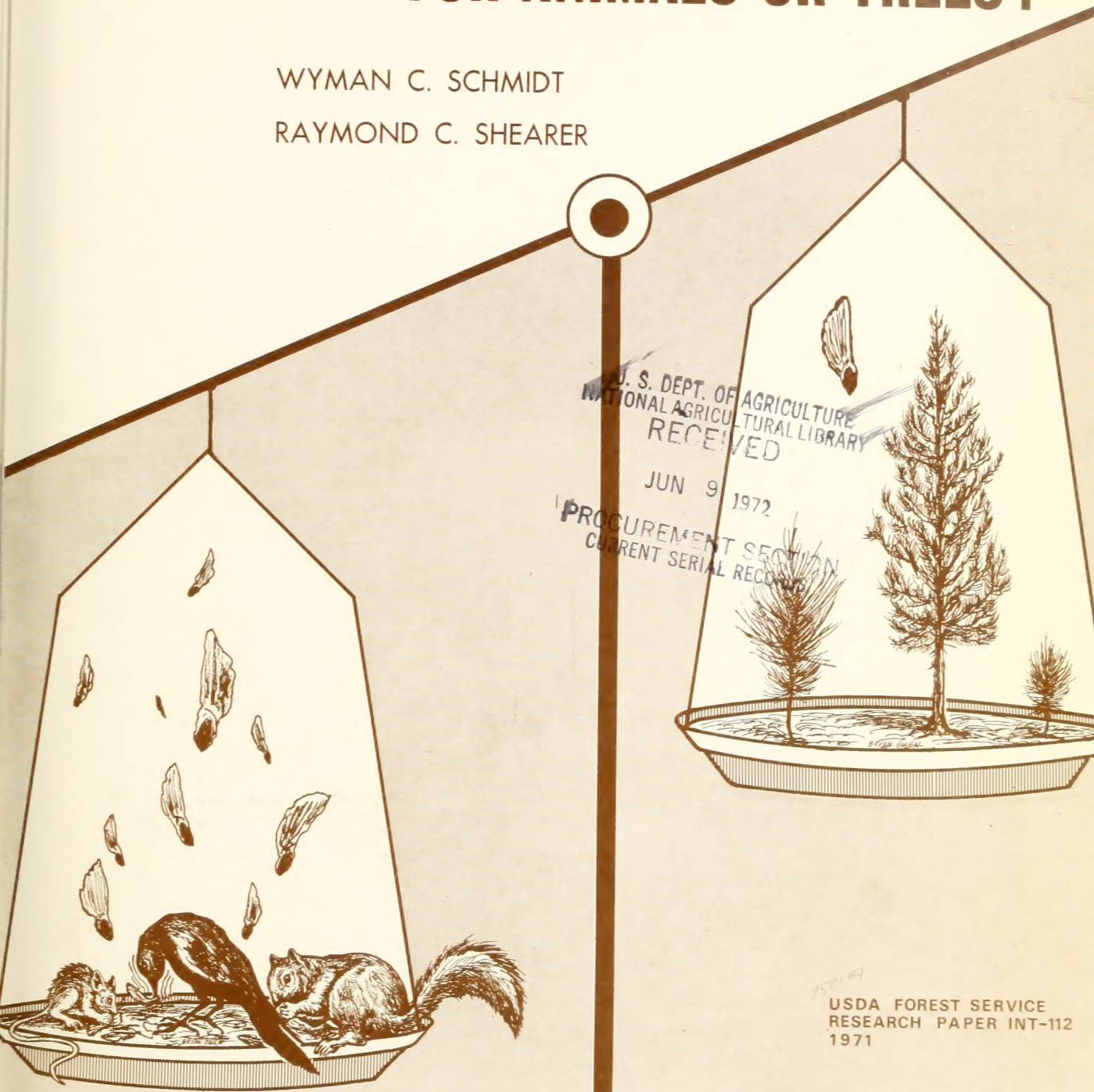

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1971

INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION

OGDEN, UTAH 84401

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PONDEROSA PINE SEED— FOR ANIMALS OR TREES?

Wyman C. Schmidt and Raymond C. Shearer

INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION
Forest Service
U.S. Department of Agriculture
Ogden, Utah 84401
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(This is a companion report of USDA Forest Service Research Paper INT-86, 1970: "Natural Regeneration in Ponderosa Pine Forests of Western Montana" by Raymond C. Shearer and Wyman C. Schmidt)

ABSTRACT

Ponderosa pine (Pinus ponderosa Laws.) seed development and survival studies in northwestern Montana showed that small forest animals reduced the potential seed crop very little during the 2-year cone development period but they consumed an average of 24 out of 25 pine seeds that matured. Red squirrels (Tamiasciurus hudsonicus richardsoni Bachman) harvested an average of 66% of the mature cones, and after the seeds were dispersed deer mice (Peromyscus maniculatus artemisiae Rhoads), chipmunks (Eutamias amoenus luteiventris Allen), and birds consumed the equivalent of an additional 30%. Deer mouse populations apparently fluctuated in direct response to the size of the previous year's seed crop.

INTRODUCTION

Red squirrels (*Tamiasciurus hudsonicus richardsoni* Bachman), deer mice (*Peromyscus maniculatus artemisiae* Rhoads), chipmunks (*Eutamias amoenus luteiventris* Allen), and birds consume large quantities of pine seeds, particularly in late summer through spring (Curtis 1948, Eastman 1960, and Smith 1943). Conifer seeds provide an important (but not always reliable) source of food for the small mammals and birds. Ponderosa pine (*Pinus ponderosa* Laws.) and Douglas-fir (*Pseudotsuga menziesii* var. *glauca* (Beissn.) Franco), two common associate species in the Northern Rockies, vary considerably from year to year in their seed crops, producing abundant yields in some years and practically none in others (Roeser 1941, Boe 1954). As a result, animals depending upon these seeds are frequently faced with feast or famine; and populations, particularly of the smaller less mobile mammals, may be affected. For example, deer mouse populations in Douglas-fir forests of Oregon apparently fluctuated in direct response to the previous year's seed crop (Gashwiler 1965). Although the feeding and caching activities of small animals and birds have been observed and reported in some coniferous forests of Oregon (Eastman 1960, Gashwiler 1967), little quantitative data concerning seed use in ponderosa pine forests of the Northern Rockies have been collected. This paper discusses (a) how several factors influence the development and production of ponderosa pine seed, (b) how much seed is used by animals, and (c) how much seed is left to regenerate a new forest.

METHODS

The extent animals and other biological and physical factors influence ponderosa pine seed development was studied during the 33-month period extending from initial ovulate bud formation until seeds are developed, disseminated, and ready to germinate. Stands composed of ponderosa pine and Douglas-fir at Bluesky Creek, Dunn Creek, and Butler Creek east of Libby in northwestern Montana provided the necessary study conditions. Based on the Daubenmires' (1968) ecological habitat system, the areas were classified:

Bluesky----------*Pseudotsuga menziesii/Physocarpus malvaceus*
Dunn----------*Pseudotsuga menziesii/Arctostaphylos uva-ursi*
Butler----------*Pseudotsuga menziesii/Calamagrostis rubescens*

Effects of Animals on Cones

Eight sample trees were selected for study of factors influencing cones during their 2-year development period. These trees averaged 20 inches in diameter at breast height (ranging from 15 to 24 inches); they were randomly selected in a partially cut-over ponderosa pine stand at Bluesky. In the upper portion of the crowns, 100 branches (10 to 15 per tree) were marked and sampled repeatedly throughout the study period. Losses of buds, conelets, and mature cones were described by cause and number for each of these stages. Four successive cone crops, maturing in 1953 through 1956, were measured four to seven times during each of their 2-year cone development periods.

Effects of Animals on Dispersed Seeds

From the time seeds are disseminated in the fall until they germinate the following spring they are available to a variety of mammals, birds, and invertebrates. To determine seed consumption during this 8-month period, the number of filled seeds remaining in the duff at the time of germination was subtracted from the number of filled seeds that fell. The amount of seedfall was determined from contents of seed traps, each of which had a surface area of 10.9 square feet. Duff samples adjacent to, and the same size as, the seed traps were removed to mineral soil in May each year, where the tree seeds were removed. This was accomplished by use of: 20 seed trap locations at Bluesky from 1948-1953 (except for 1952); five locations each at Dunn and Butler in 1951; 10 locations each at Dunn and Butler in 1953; and 10 locations at Dunn in 1954. Bluesky and Dunn had been partially cut but there had been no cutting at Butler.

To determine the species composition and relative abundance of the principal seed-eating mammals, the Bluesky area was snap-trapped for three nights twice annually--in the fall and in the spring--from 1948 to 1954. Common snap traps (using ponderosa pine seed, bacon, and rolled oats as bait) were set in groups of three at 20 stations in each of three rows. Stations were 25 feet apart. Feeding preferences of the small mammals were determined by Adams (1950) with stomach examinations.

RESULTS AND DISCUSSION

Several biological and physical factors drastically reduced the potential number of seeds available for animals, and they in turn further reduced the number available for germination. To illustrate this reduction of the seed crop, the results are presented in a time sequence, starting at the time of initial ovulate bud formation and ending just before seed germination. This 33-month period is diagramed to identify and show how the most important factors affected cone and seed survival throughout the sequence (fig. 1). The two important time segments emphasized in these discussions are: (a) before seed dispersal when red squirrels were the most important predator; and (b) after seed dispersal when ground-dwelling rodents were most important.

Effects of Animals on Cones

During the 4 cone years studied, only about one-fourth of the potential cones survived the first year of development (fig. 2). First-year cone survival ranged as high as 48 percent for the prospective 1956 crop and as low as 3 percent for the 1955 crop. Animals had little to do with this high mortality; abortions were primarily responsible, reducing the potential cone crop nearly two-thirds. Abortion rates ranged as high as 73 percent for the 1954 cone crop and as low as 21 percent for the 1956 crop. The causes of these extremely large and variable abortion rates were not determined.

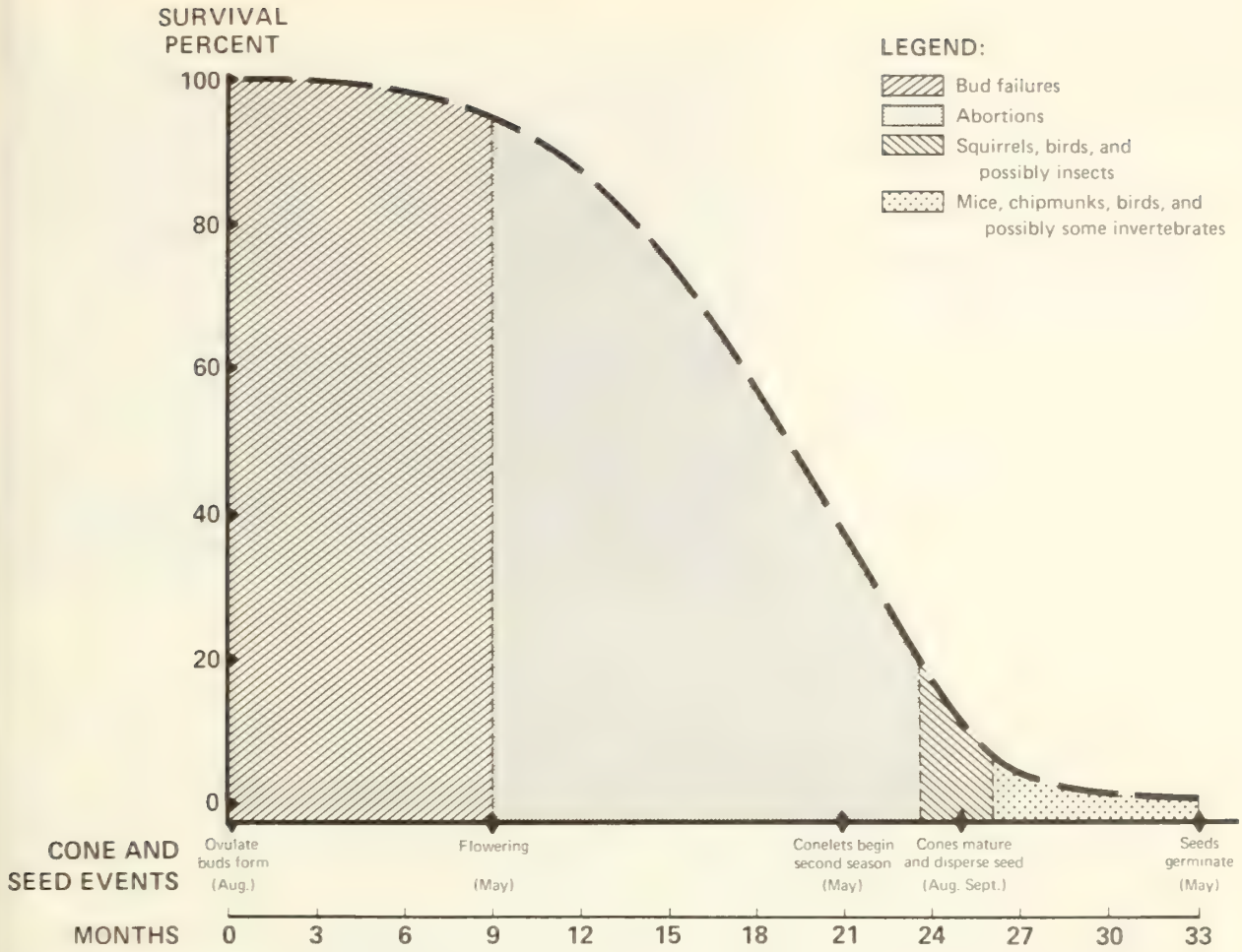

Figure 1.--Cone and seed development sequence of ponderosa pine and the most important factors affecting their survival during a 33-month period. Survival percent based on the potential seed crop present in the initial ovulate buds.

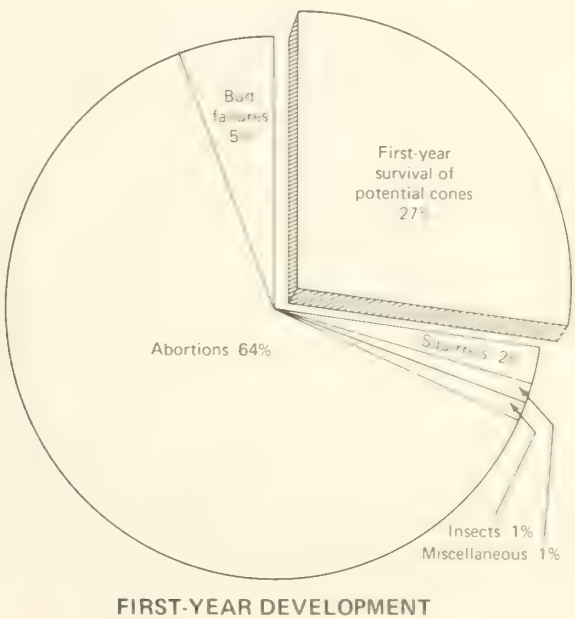

Figure 2.--Factors affecting the survival of ponderosa pine cones during their first year of development.

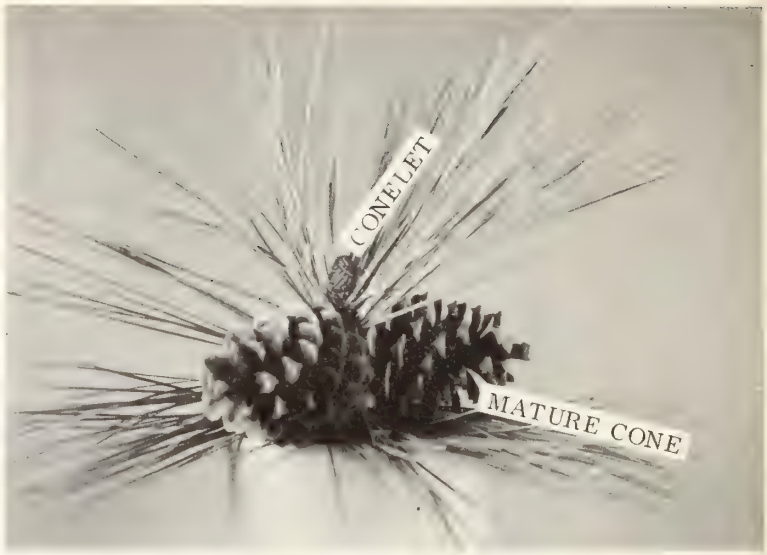

Figure 3.--Squirrels severed this ponderosa pine shoot to harvest the mature cones. The small conelet that would mature the next year, and the ovulate buds that would mature in 2 years (not shown here), are destroyed by such cutting.

First Year of Cone Development

Red squirrels were the only animals affecting the cones during the first year of cone development. These annual losses ranged from 0 to 8 percent, averaging less than 2 percent for the four cone crops. Because of the immaturity of the cones in the first year, it is unlikely the squirrels were specifically seeking them in their food forays. Rather, the cutting of immature cones was more likely due to their being located nearer the tip of the shoot beyond mature cones of the current season (Squillace 1953). In most cases, squirrels severed the entire cone-bearing shoots just below the current mature cone; thus, immature cones and ovulate buds were accidentally destroyed. Such indiscriminate cutting by the squirrels can adversely affect 3 years of cone production represented by the ovulate bud, immature cone, and mature cone (fig. 3). Squirrels also sever the ends of pine branches in the winter to feed on the cambium and, in the process, destroy some of the partially developed cones (Adams 1955).

Second Year of Cone Development

Of the cones that survived the first year of development, only about one-fourth survived the second year (fig. 4). Squirrels were responsible for most of the cone

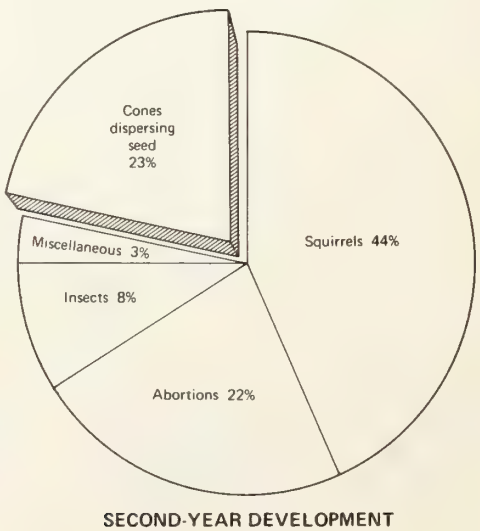

Figure 4.--Factors affecting the survival of ponderosa pine cones during their second year of development.

SCHMIDT, WYMAN C. and SHEARER, RAYMOND C.

1971. Ponderosa pine seed--for animals or trees, USDA Forest Serv. Res. Pap. INT-112, 14 p., illus.

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reduction during this period; they cut nearly half of the cones. Yearly values, however, ranged from a low of 19 percent in 1954 to a high of 82 percent 2 years later, as shown by the following tabulation:

Cone year	*Number of cones*	*Percent cones harvested*
1953	128	54
1954	125	19
1955[1]	--	--
1956	49	82
Average	101	44

Previous squirrel-cutting records reported by Squillace (1953) were based on the number of *mature* cones available to the squirrels; consequently they were higher, as shown below:

Year	*Number of mature cones*	*Percent cones harvested*
1951	144	77
1952	9	89
1953	80	85
1954	80	30
1955[2]	--	--
1956	41	98
Average 1953-56		66
1951-56[3]		71

Squirrel-cutting patterns varied from year to year and were difficult to interpret. It was apparent that if mature cones were available, squirrels would harvest at least some of them. However, the amount of their cutting was not necessarily related to total size of the pine cone crop. The size of Douglas-fir cone crops appeared to influence the amount of squirrel-cutting activity in the pine. For example, in 1954, fir produced a heavy cone crop and squirrels cut only 19 percent of the pine cone crop. When the fir crop failed in 1956, the squirrels cut 82 percent of the light pine cone crop. In 1953, when fir produced a light crop, a more moderate percentage (54 percent) of the pine was cut. Seeds of Douglas-fir apparently constituted an important segment of the squirrel's diet.

Although the size of the Douglas-fir cone crop appeared to strongly influence the cutting in pine, other factors might have been involved. Halvorson's (1966) observations on Cedar Island, Flathead Lake, Montana, indicate that squirrels may harvest fewer cones in the moist, cool falls than they do in the dry, warm falls. The small percentage (19 percent) of pine cones harvested by squirrels in 1954, the moderate percentage (54 percent) in 1953, and the large percentage (82 percent) in 1956 support this observation; the fall of 1954 was moist and cool, the fall of 1953 was about average, and

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[1]None of the cones that would have matured in 1955 survived the first season of development.

[2]No cones reached maturity in 1955.

[3]Includes Squillace's (1953) results.

the fall of 1956 was warm and dry. Thus, it is not entirely clear if weather conditions, size of the Douglas-fir crop or a combination of these two, abundance of other desirable foods, or other factors might have accounted for the annual differences in pine cone cutting by squirrels.

The period of squirrel cutting extended from mid-July to the period of maximum seed dissemination in September. During 1953, squirrels cut 15 percent of the crop before August 3. Most of the cones cut early in the season were used immediately, but the cones cut just before maximum seed dissemination were cached (Squillace 1953). Halvorson (1965) indicated that squirrels use cones from these caches over periods of 2 years or longer.

Abortions also reduced the number of surviving cones substantially during the second season of cone development. Even though the number of abortions dropped considerably from that in the first season, abortions still accounted for a surprisingly high 22 percent reduction over the 4 cone years studied--exceeding 10 percent every year when cones remained at the beginning of the second growing season.

Like squirrels, insects played a more important role in the second year than they did in the first year of cone development. Unidentified insects accounted for an average of 8 percent (ranging from 5 to 12 percent) of the mortality during the second season of cone development. Although not measured in these studies, birds and chipmunks probably harvested some seeds from the mature cones before the seeds were all disseminated.

Total Cone Development Period

Based on the total potential cone crop present in the original ovulate buds, only 6 percent of the cones survived the 2-year development period to disseminate seeds (fig. 5). Abortions were by far the most important limiting factor (70-percent reduction); most of this loss occurred in the first year. Squirrels were an important factor in the second season, but in relation to the total original potential they accounted for only 14 percent of the total reduction. Insects, bud failures, and other unidentified factors accounted for the remaining 10 percent of the reduction.

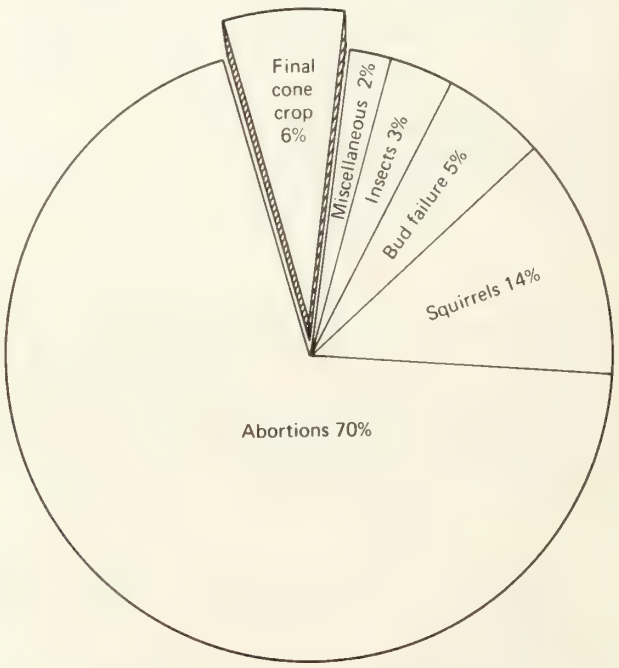

Figure 5.--Factors affecting the survival of ponderosa pine cones during their entire 2-year cone development period.

Table 1.--*Number of sound ponderosa pine and Douglas-fir seed dispersed and consumed per acre, by year, Kootenai National Forest (number of seeds given in thousands)*

Seed year[1]	Number of plots[2]	Ponderosa pine seed		Douglas-fir seed	
		Dispersed	Consumed[3]	Dispersed	Consumed
1948	20	75,400	69,600 (92)	3,000	1,800 (60)
1949	20	7,800	6,400 (82)	79,600	78,600 (99)
1950	20	0	0 --	3,900	3,900 (100)
1951	30	4,200	3,000 (71)	100	100 (100)
1952[4]	--	--	--	--	--
1953	39	7,100	6,300 (89)	10,400	9,200 (88)
1954	10	23,600	18,800 (80)	187,200	170,400 (91)
Total seed		118,100	104,100 (88)[5]	284,200	264,000 (93)[5]

[1]1948-50 data were from Bluesky; 1951 and 1953 data from Bluesky, Butler, and Dunn; and 1954 data from Dunn.
[2]Quarter milacre in size.
[3]Values in percent shown in parentheses.
[4]No data taken.
[5]Average.

Effects of Animals on Dispersed Seeds

As soon as ponderosa pine and Douglas-fir seeds fell to the ground in early September, small animals began to eat or cache them. Regardless of the size of the seed crop available, they consistently consumed the majority of the filled seed, never taking less than 70 percent of the total number available. Over the 6-year study period, animals consumed about 90 percent of the pine and fir seeds before they could germinate in May (table 1). For example, 75,400 sound pine seeds and 3,000 sound fir seeds were dispersed per acre in 1948; this was a good seed crop year for pine but a poor one for fir. About 69,600 pine (92 percent) and 1,800 fir (60 percent) were consumed before May 1949 (Squillace and Adams 1950). The methods used did not separate bird and invertebrate feeding from that of the small mammals.

Of the mammals, deer mice apparently consumed most of the seed. They were 3 to 4 times more abundant than the combined total of all the other five species of small mammals found on the study area. In addition, stomach analyses of all small mammals on this study area by Adams (1950) indicated that only deer mice and chipmunks ate many seeds. Other small mammal species he found on the area included:

Longtailed meadow mouse (*Microtus longicaudus mordax* (Merriam))
Kootenai redbacked vole (*Clethrionomys gapperi saturatus* (Rhoads))
Rocky Mountain vole (*Phenacomys intermedius intermedius* (Merriam))
Gray shrew (*Sorex cinereus* (Kerr)).

Deer mouse populations apparently responded to the size of the previous year's pine and fir seed crop. Mice reproduce frequently and their population can respond rapidly to increased food supplies. Figure 6 supports this hypothesis when the average catch of these mice per 100 trap nights at Bluesky is compared with the pounds of conifer seed dispersed per acre the previous year. For example, from 1949 to 1950, the mouse population declined from nearly seven animals per 100 trap nights to less than three--similar in magnitude to the drop in seed crop from 1948 to 1949. In 1951, the mouse population reached its lowest point, probably because of the extremely small seed crops (both pine and fir) in 1950. A fair seed crop of pine in 1951 was followed by a recovery in the numbers of mice caught in 1952. The 1952 conifer seed crop was poor; however, the mouse population did increase in 1953. Heavy crops of other desirable foods might have been available that year.

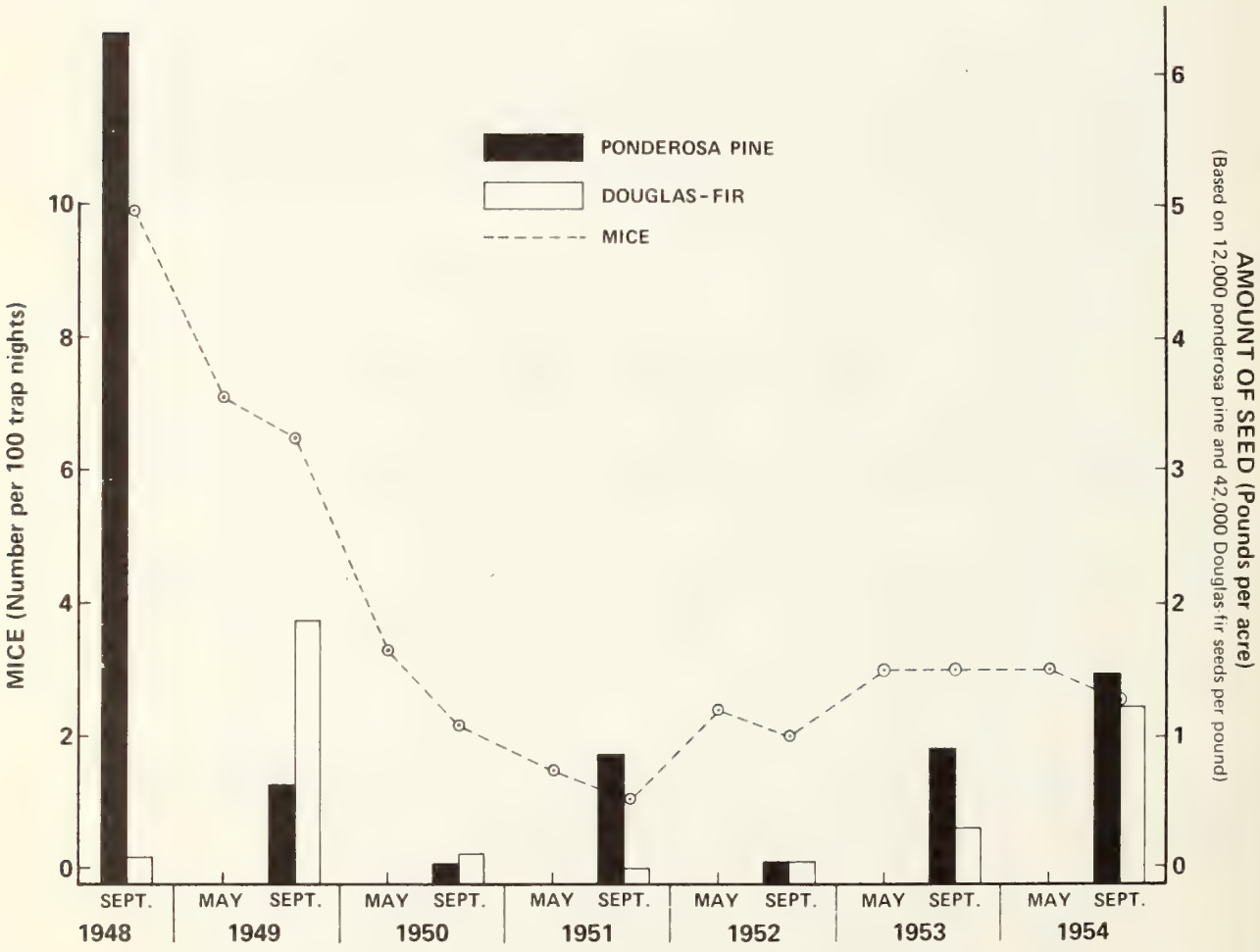

Figure 6.--Comparison of the number of mice trapped per 100 trap nights and the amount of seed dispersed per acre, Kootenai National Forest, 1948-1954.

CONCLUSIONS

Most ponderosa pine seeds that reach maturity are eaten by animals. Out of 25 seeds that reach maturity, 24 provide one of the sources of energy for the small forest animals; the single remaining seed is available for germination.

Red squirrels, chipmunks, and birds have first chance at harvesting mature seeds in the cone. Ground dwelling mammals, ground feeding birds, and invertebrates must search for the seed remaining on the forest floor. Squirrels have a survival advantage in that they can cache cones from a good cone crop and keep them in storage for 2 years or longer, while the other small mammals and birds must use the current supply of seed before it germinates in the spring.

Pine and fir seeds constitute an important part of the diet of the small animals inhabiting these forests. How much food in the form of tree seeds does a mature ponderosa pine--Douglas-fir forest produce? On a per-tree basis, mature ponderosa pine trees under natural forest conditions produce about 125 cones per tree and about 60 sound seeds per cone in a moderate seed year--nearly two-thirds of a pound per tree.

If by chance a fair seed crop year for both pine and fir occurs concurrently in the forests of northwestern Montana, approximately 2 pounds of sound pine seed per acre (24,000 seeds) and about 2 pounds of sound fir seed per acre (84,000 seeds) might mature. Of this 4 pounds, squirrels and cone-feeding birds eat or cache about 2.8 pounds, and 1.2 pounds are dispersed, of which small mammals and birds consume about 1.1 pounds. Thus, about 0.1 pound (about 600 pine and 2,100 fir seeds) is available for tree regeneration. A good seed crop of both species concurrently would about triple these amounts. However, good seed crops of both species are infrequent (about every 3 to 5 years) and they seldom occur in the same year; thus, the total amount of conifer seed available annually for animals would seldom exceed the total amounts described above for a fair seed crop year.

Because chipmunks cache some ponderosa pine seeds they never recover, the amount consumed might be slightly less and the amount available for germination might be somewhat greater than indicated. West (1968) found that up to 15 percent of the ponderosa pine seedlings in central Oregon resulted from seed caches not consumed by the animals.

Although animals play the most obvious dramatic role in seed production, they act only during the last 9 or 10 months of a 33-month cycle that terminates at the beginning of seed germination. During the 2 years prior to germination, the seed users are far overshadowed in importance by more subtle factors. Large potential cone crops are drastically reduced by abortions; thus a population explosion of trees is prevented long before animals begin harvesting the seeds. However, after the seeds mature, animals become very important and efficiently utilize this available food, as shown in the following tabulation:

Description	*Percent*	*Number*
Seeds reaching maturity		100
Seeds used by animals before dispersal	66	66
Seeds dispersed		34
Seeds used by animals after dispersal	88	30
Seeds available for germination		4

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